



U.S. Army Research, Development and Engineering Command



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Frank Campo
Mark Miller
Joe Walden
Benet Laboratories
US Army RDECOM ARDEC

Chromium Elimination and Cannon Life Extension for Gun Tubes

ESTCP WP-201111
ASETSDEFENSE OVERVIEW
August 30, 2012

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 AUG 2012		2. REPORT TYPE		3. DATES COVERED 00-00-2012 to 00-00-2012	
4. TITLE AND SUBTITLE Chromium Elimination and Cannon Life Extension for Gun Tubes				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Army Benet Laboratories,Picatunny Arsenal,NJ,07806				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES ASETSDefense 2012: Sustainable Surface Engineering for Aerospace and Defense Workshop, August 27-30, 2012, San Diego, CA. Sponsored by SERDP/ESTCP.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 24	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



Project Team

Key Performers

Mr. Frank Campo
Mr. Mark Miller
Mr. Edward Troiano
Dr. Joseph Walden
Stephen Smith
Dr. Chris Mulligan
Mr. Michael Audino
Dr. John Underwood
Dr. Tony Parker
Mr. Arthur Aeberli
Mr. David Le
Mr. Mike Ellis
Dr. Keith Legg
Mr. Mark Witherell
Dr. William de Rosset
Dr. Jonathan Montgomery
Mr. Josh Hydrew
Mr. Don Butler

Organization

U.S. Army Benet Laboratories
U.S. Army Benet Laboratories
U.S. Army Benet Laboratories
U.S. Army Benet Laboratories
U.S. Army Benet Laboratories
U.S. Army Benet Laboratories
U.S. Army Benet Laboratories
U.S. Army Benet Laboratories
U.S. Army Benet Laboratories
Royal Military College of Science
U.S. Army Medium Cal Weapons
U.S. Army Aberdeen Proving Grounds
U.S. Army Medium Cal Ammo
Rowan Technology Group
U.S. Army Benet Laboratories
U.S. Army Research Laboratory
U.S. Army Research Laboratory
ARES Inc.
High Energy Metals, Inc.

Function

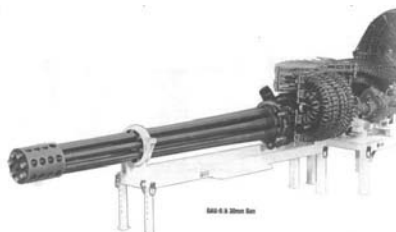
PI Program Manager
PI Material Science
Material Science
Material Science
Material Science
Material Science
Technical Adviser
Material Science
Material Science
APO-Technical Adviser
Material Science
Technical Adviser
Cost Data Collection
Thermal Modeling
Explosive Analysis
Material Science
Manufacturing
Cladding Technology

- **To eliminate the use of hexavalent chromium (VI) in the production of cannon barrels by developing a cost effective environmentally friendly Explosive Bonding process.**
- **To demonstrate and validate the effectiveness of a cannon tube explosively clad with tantalum-10 tungsten (Ta-10W) liner to decrease erosion and increase performance and extend the lifecycle.**
- **The baseline for testing is a chromium plated gun tube.**



RDECOM

Technical Approach



**High Rate GAU
Cannon Systems**



**BFV
25mm M242 Cannon**



M242 Bases C-RAM

**Explosive Bonding
Technology could
potentially be used
on the following
Legacy and New
Weapons Systems
Platforms.**



Mk 38 Tactical Standoff Systems



**Future GFV
30-50mm Cannons**



**High Mobility
Weapons**

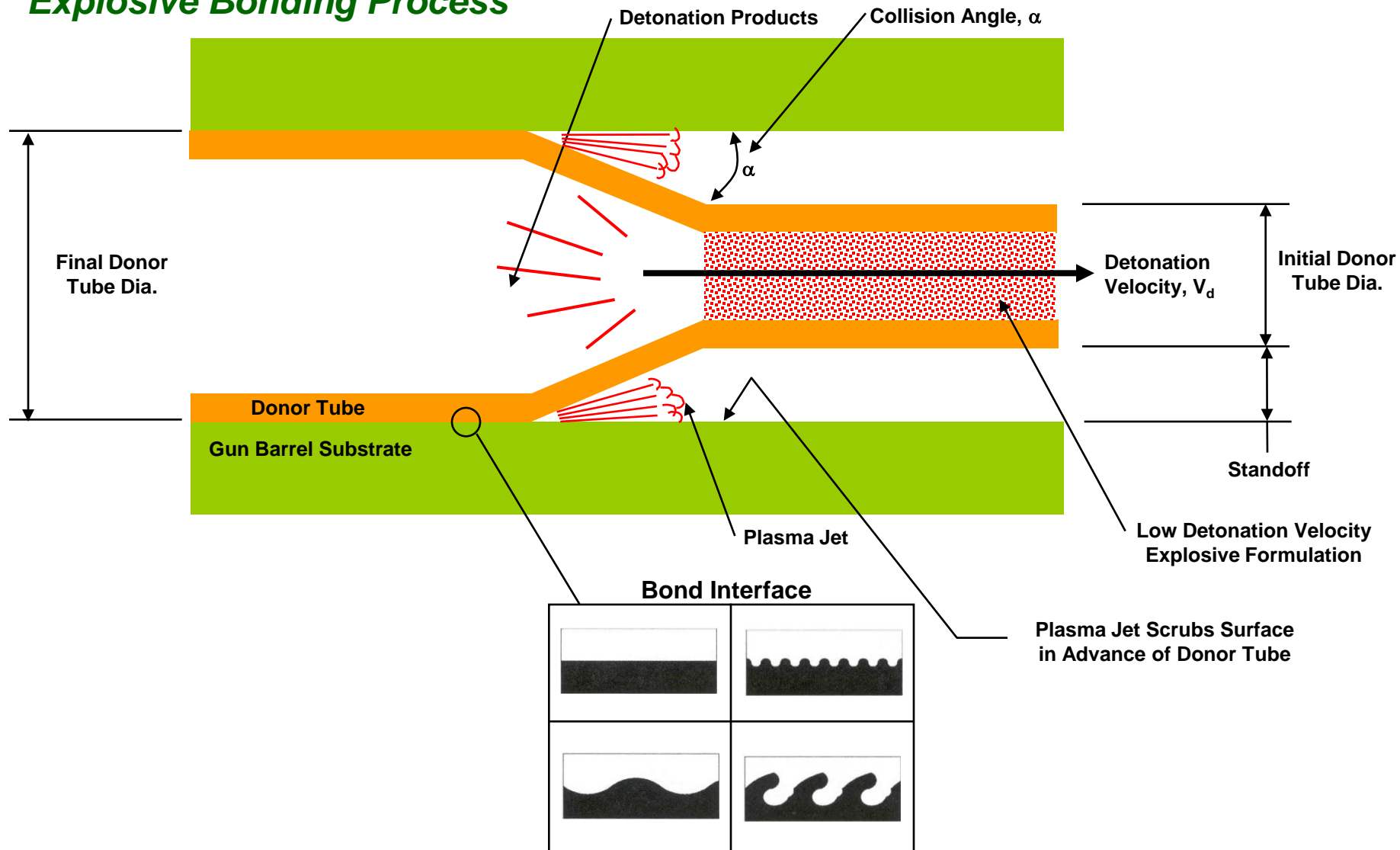


**Large Caliber Recoilless
Cannon Systems**

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

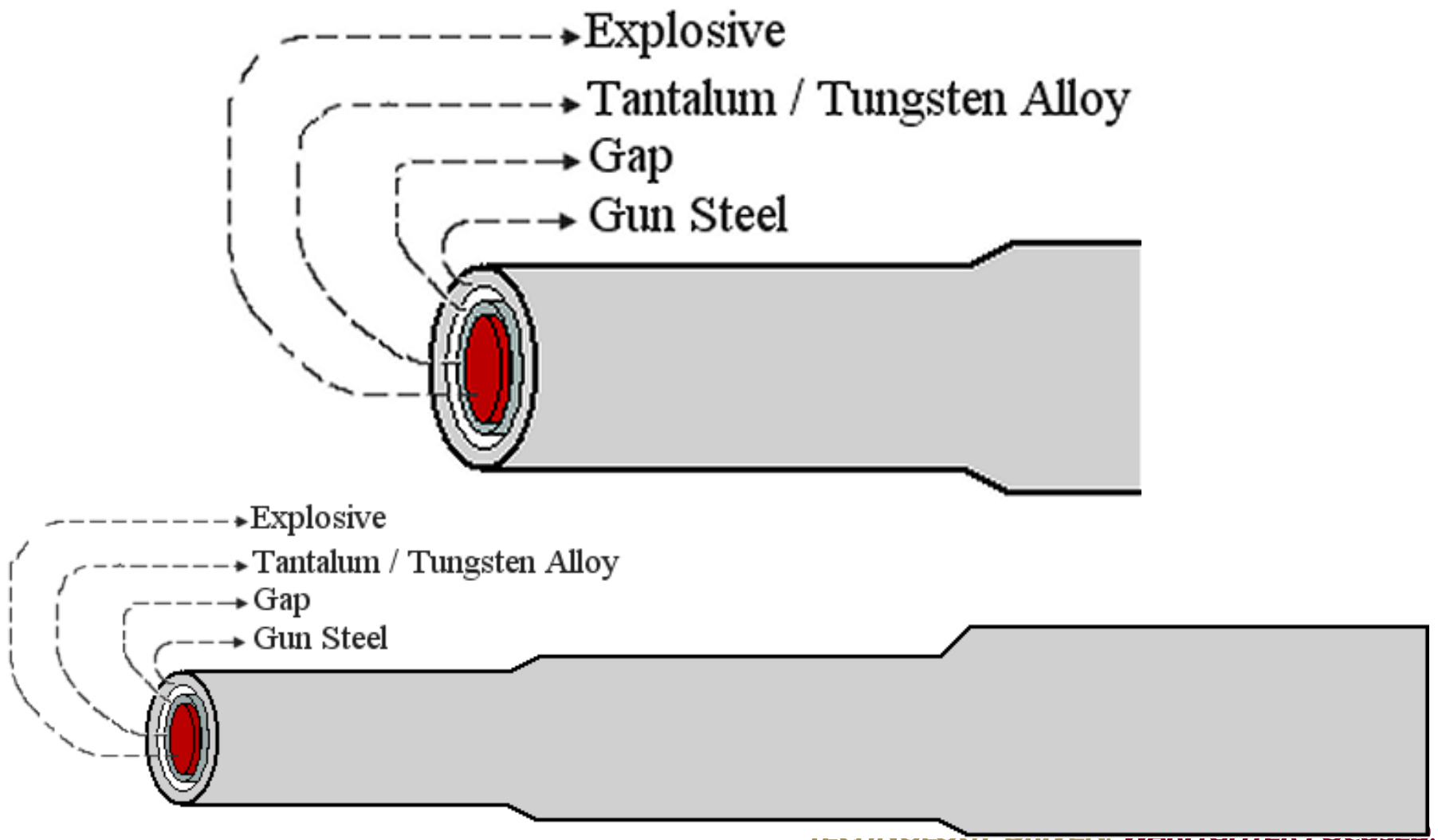
Technical Approach

Explosive Bonding Process

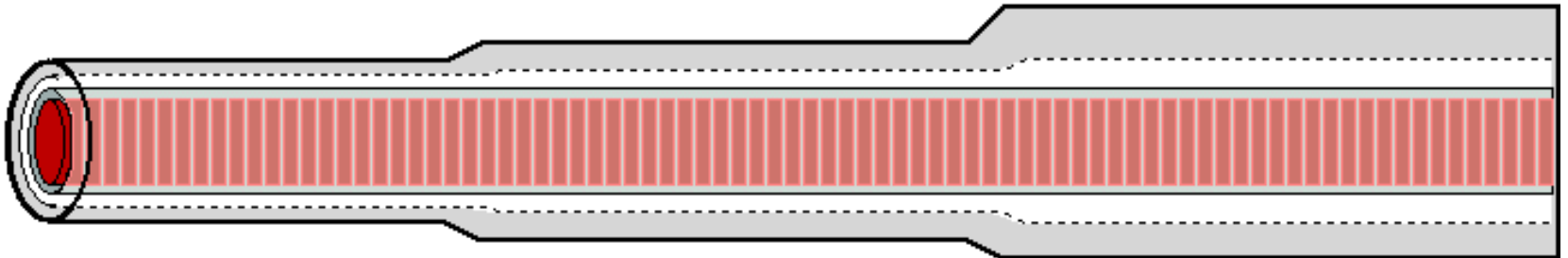




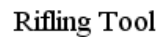
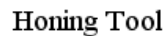
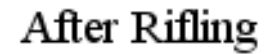
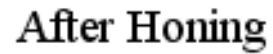
Explosive Bonding Process



Explosive Bonding Process

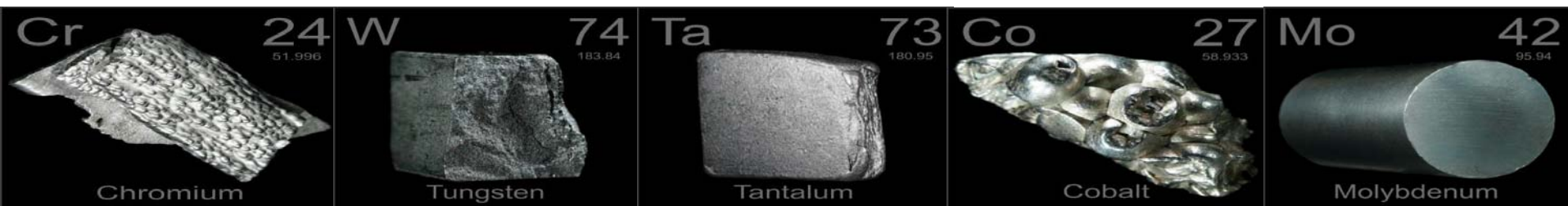


Before Honing





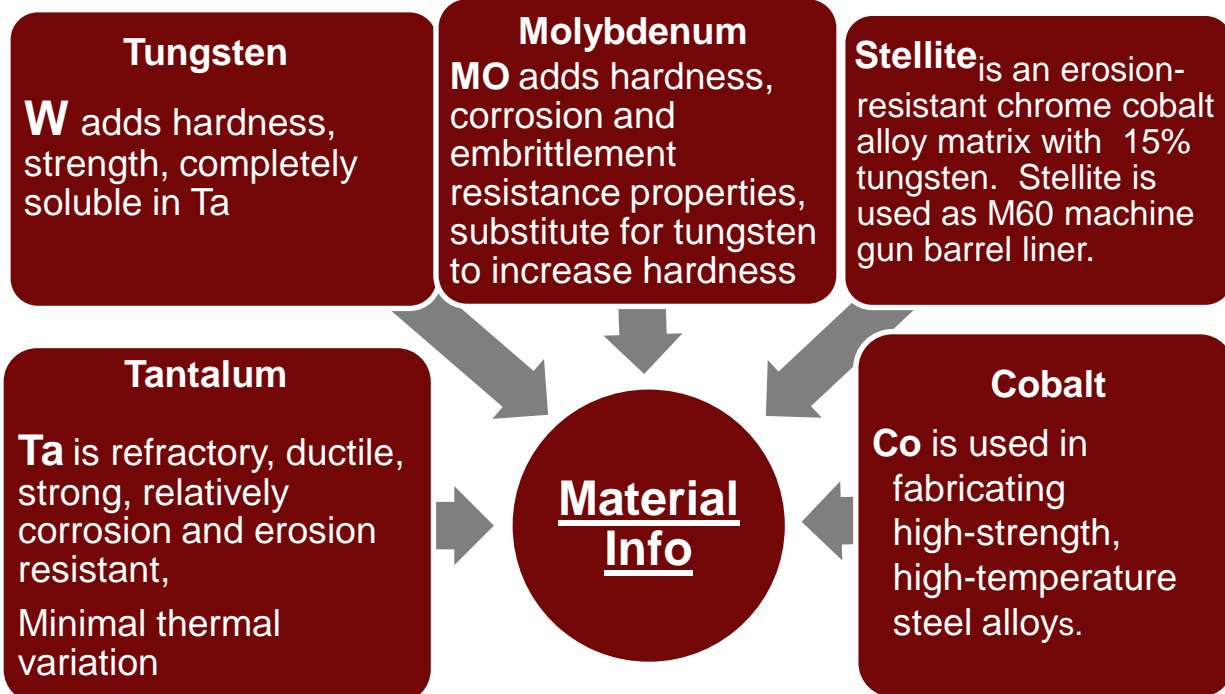
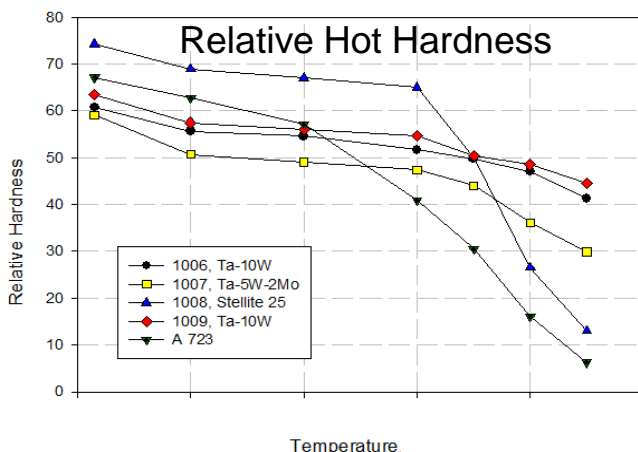
Technical Approach



Melting Point 1857 °C Melting Point 3422 °C Melting Point 3017 °C Melting Point 1495 °C Melting Point 2623 °C

Material Selection Goals:

1. Increased surface hardness for improved wear resistance
2. Reduced chemical reactivity including hydrogen embrittlement
3. Increased erosion resistance
4. Enhanced machinability to accommodate rifling
5. Reduce interface intermetallics





RDECOM

Technical Approach



Gun Steel to Ta-10W Bond Line



**Section of 18" Truncated Barrel
Ta-10W Donor Tube "Liner"**



**Sectioned 18" Truncated Barrel
Cladded with Ta-10W**

Major Progress/Accomplishments 2011-2012

- **Demonstrational Test Plan for ESTCP Program WP-20111**
 - Developed, approved, and initiated
- **Firing Test Plan - JTP**
 - Developed and approved by ARDEC Medium Caliber Gun and Ammo Division
 - approved by APG
- **M242 25mm Barrels Fabricated**
 - S/N 101: Ta-10W
 - S/N 102: Ta-10W
 - S/N 103: Ta-10W
 - S/N 104: Ta-10W
- **Firing Test Conducted at YPG - High Energy Ammo Tests**
 - SN101 Ta-10W - using M919 and M791
 - SN7039 - using M919 and M791
- **Develop Advanced NDT Techniques for Weapon Systems**
I E. :UT CSCAN, CT-XRAY, 3D Measurements, EBIS

Demonstration Site:

Yuma Proving Grounds (YPG)

Preliminary proof of principle endurance testing at YPG shows promising results when conducted side by side to a chrome plated barrel.

The chrome barrel was condemned at 3,650 rounds.

At more than 12,000 rounds the Ta-10W tube.

The chamber was shown to be less than 1/3 worn when compared to the condemned chrome barrel.

Virtually no wear on the tubes lands.

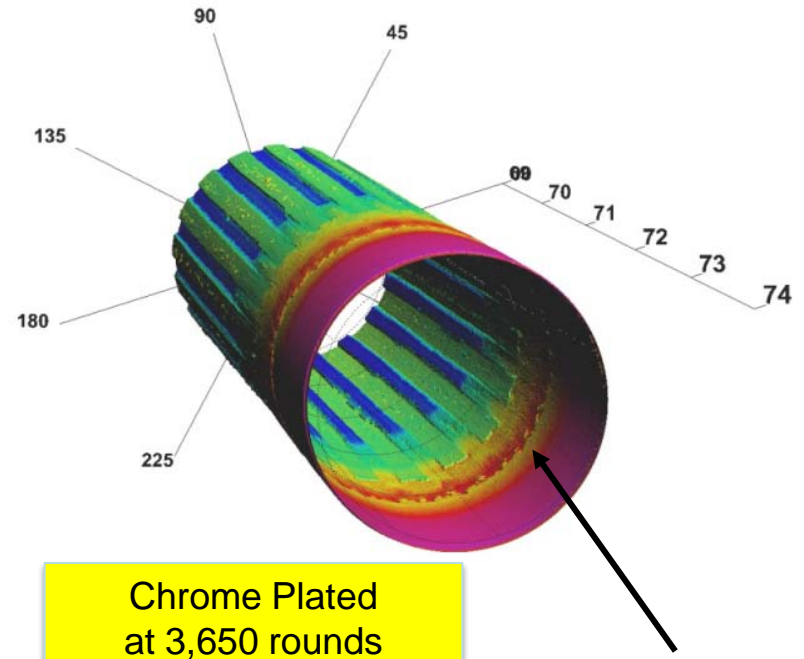


**Endurance Testing GP-20
Medium Caliber Range YPG**
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

180
135
90
72
73
74
315
270
225
135

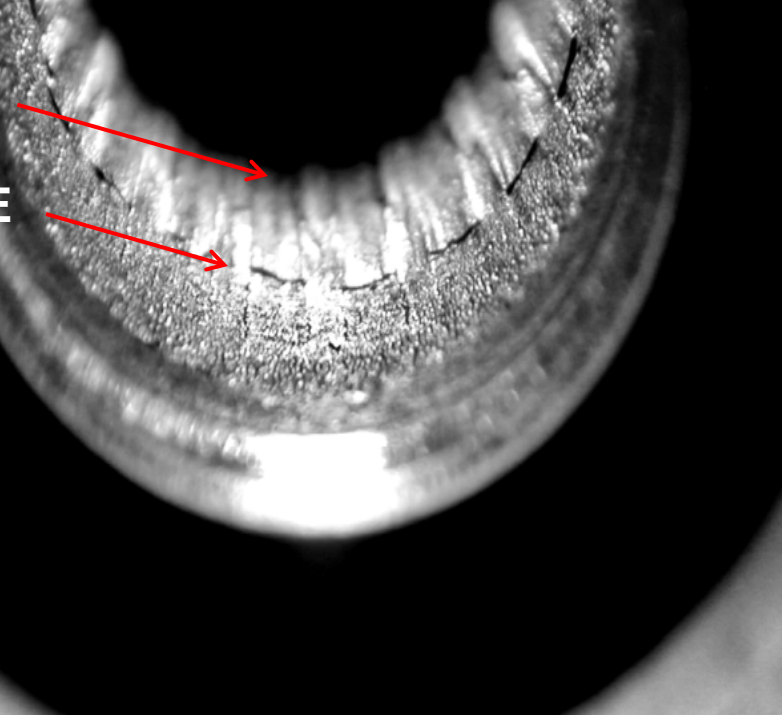
VI
ER

VIRTUALLY NO EROSION ON ID OF GUN STEEL



**WORN REGION
BELOW BORE ID
STEEL SURFACE**

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



AND
OVE

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



Technical Progress

NDT Recording Precision Measurements Over a Weapons Lifecycle



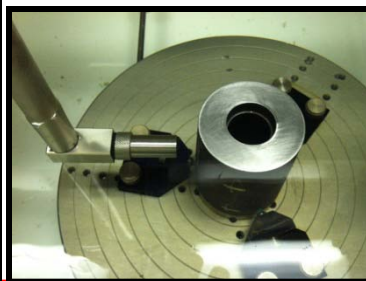
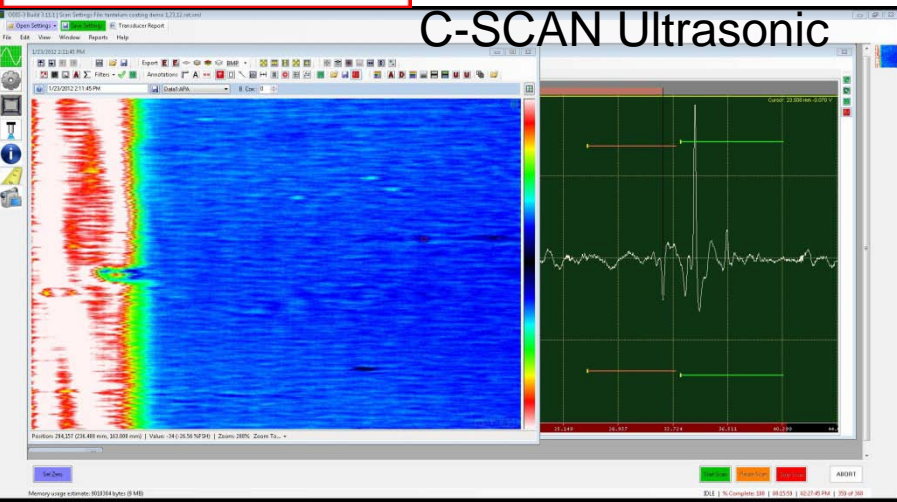
ARL-Aberdeen, MD

3D Optical Deformational
Analysis



Faro 3D CMM

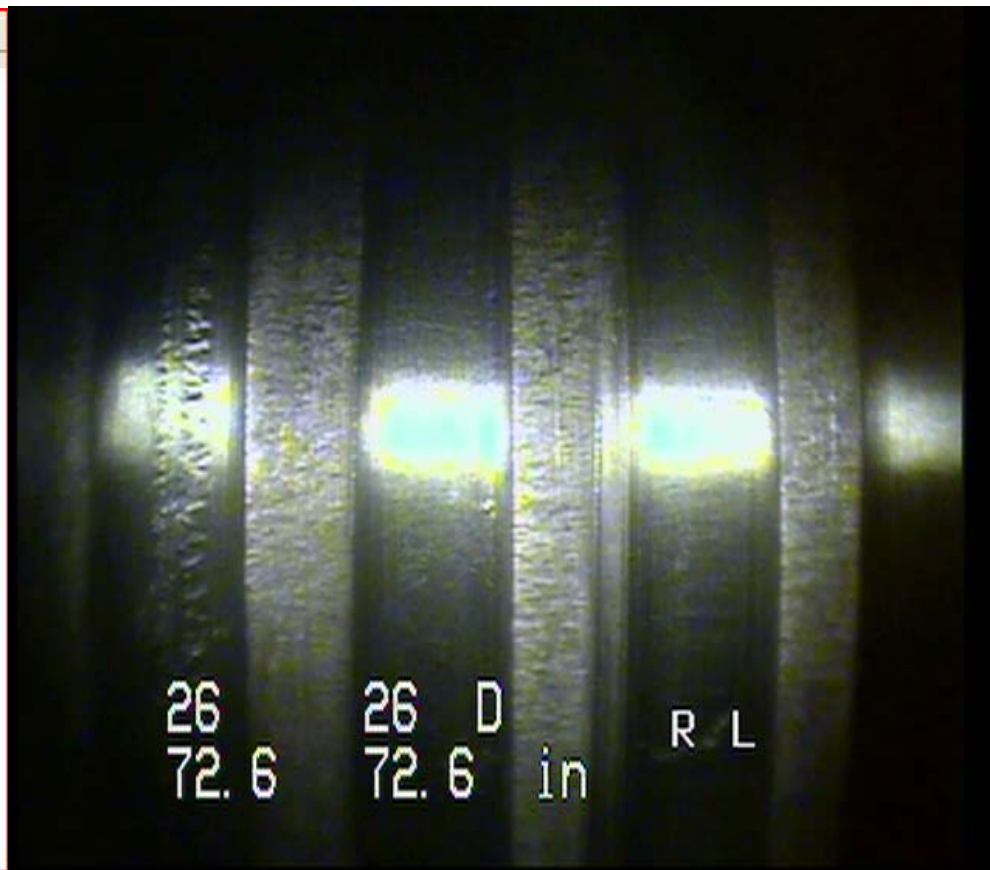
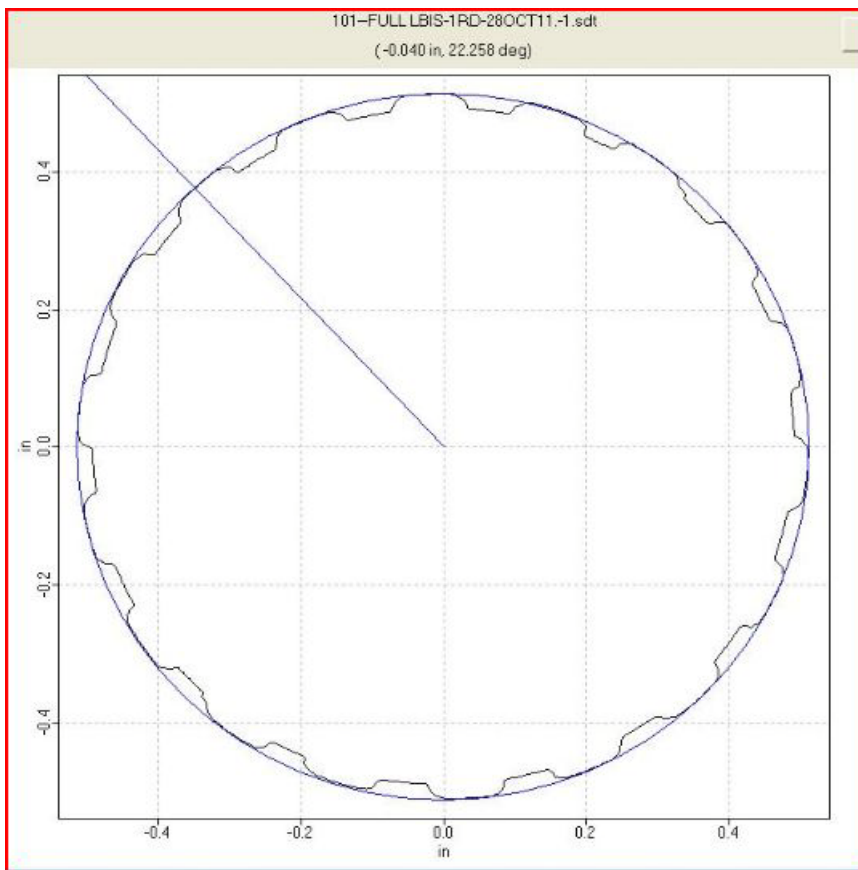
C-SCAN Ultrasonic



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Firing Test Conducted at YPG - High Energy M919 Ammo Tests

Pre-Inspection – S/N 101: Ta-10W



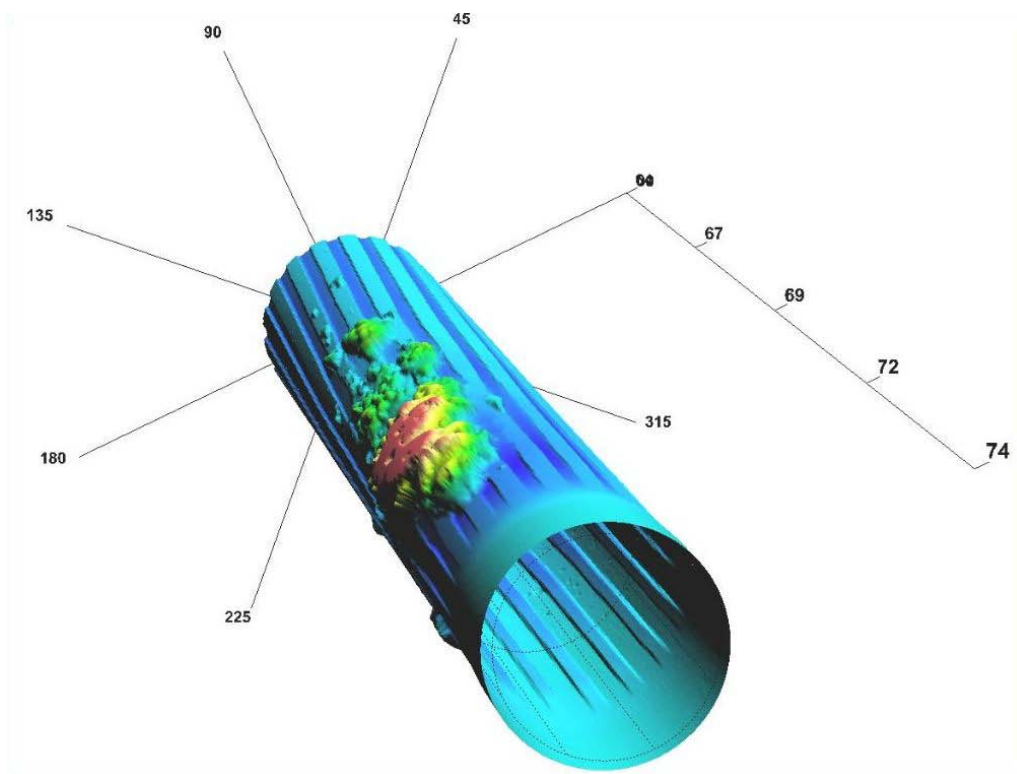


Technical Progress

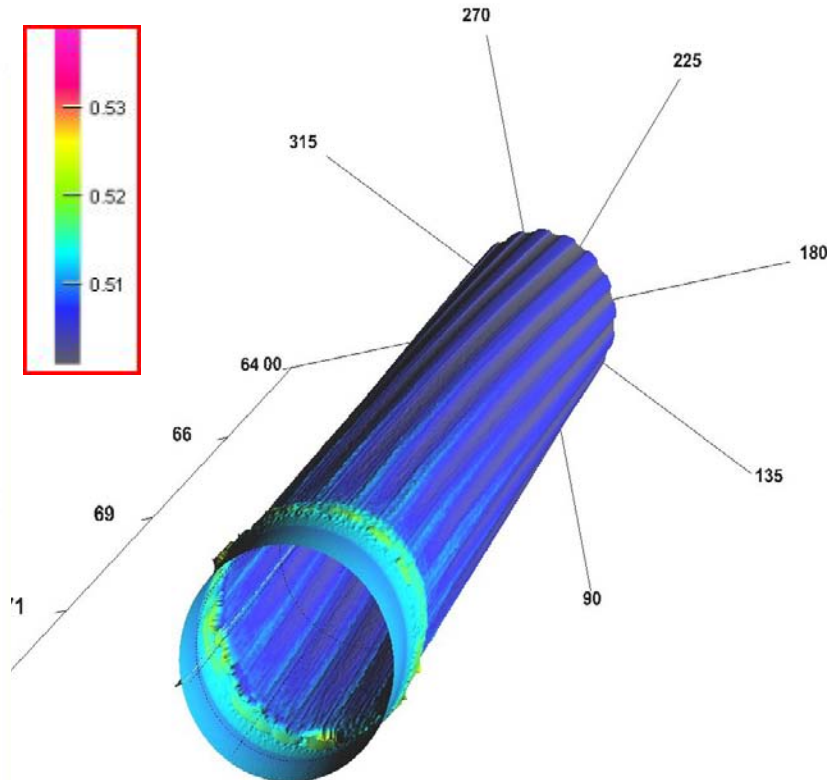
Firing Test Conducted at YPG - High Energy Ammo Tests

1. Visual Observations cont'd,

Chrome Tube 741 Rounds

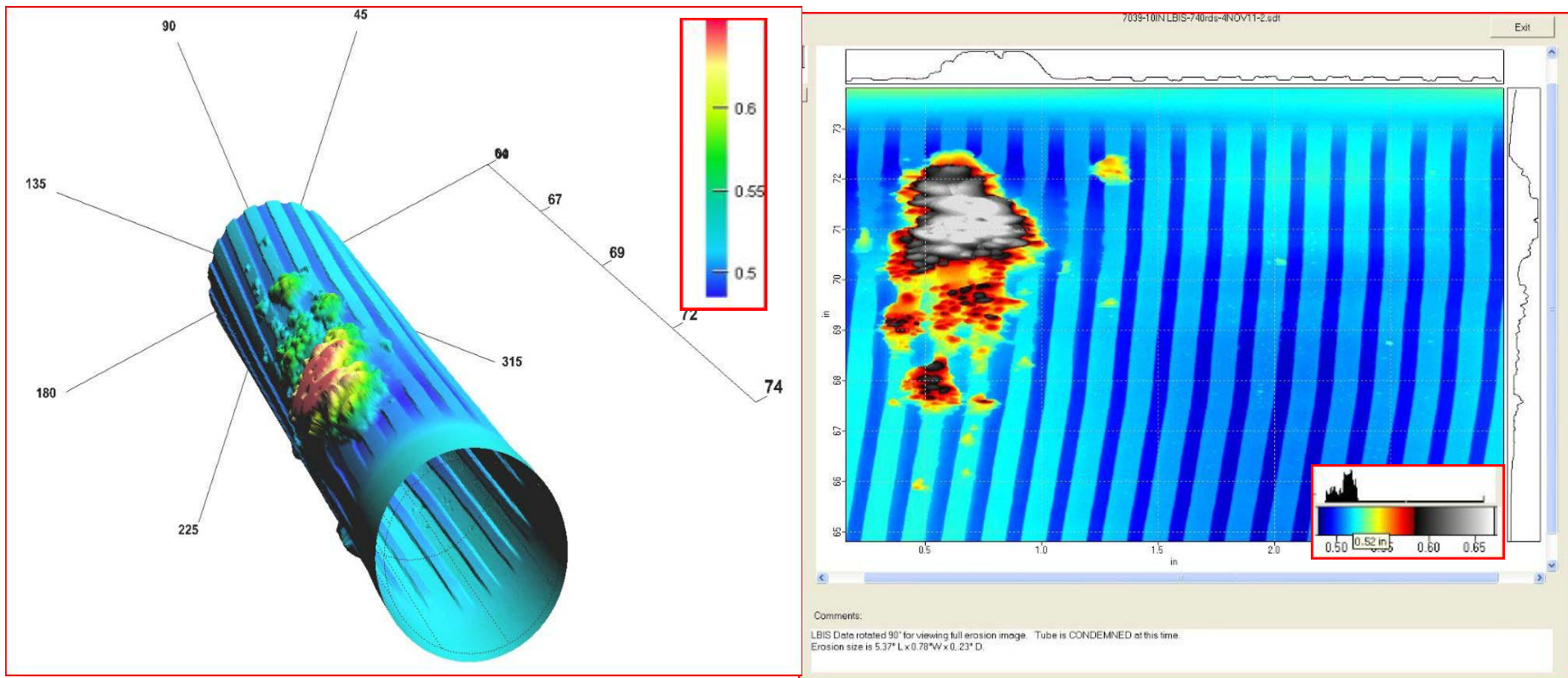


Ta-10W 900 Rounds



Firing Test Conducted at YPG - High Energy M919 Ammo Tests

1. Visual Observations – Chromium Tube at 740 Rounds



Post Firing - Inspection Catastrophic Failure at 740 rounds

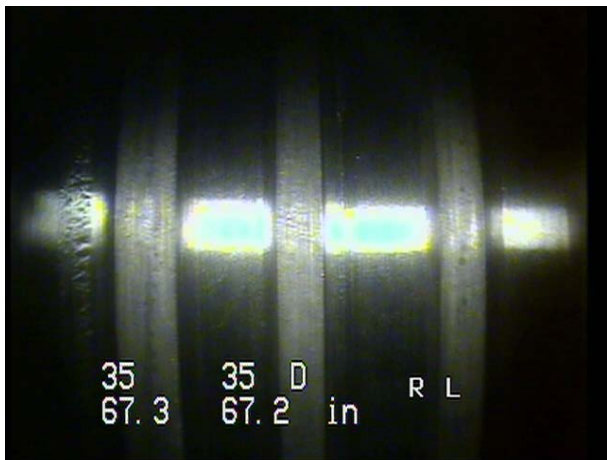
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



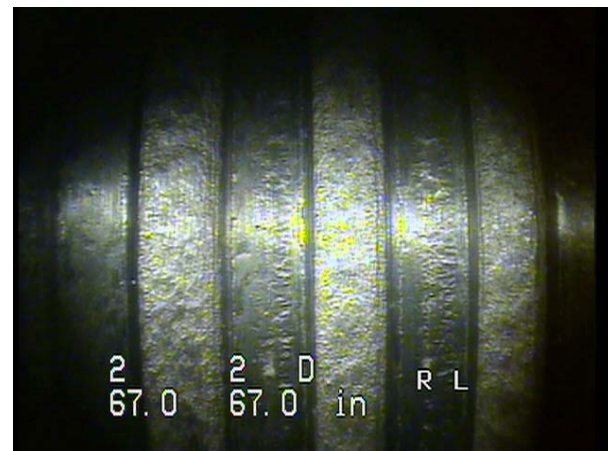
Technical Progress

Firing Test Conducted at YPG - High Energy M919 Ammo Tests

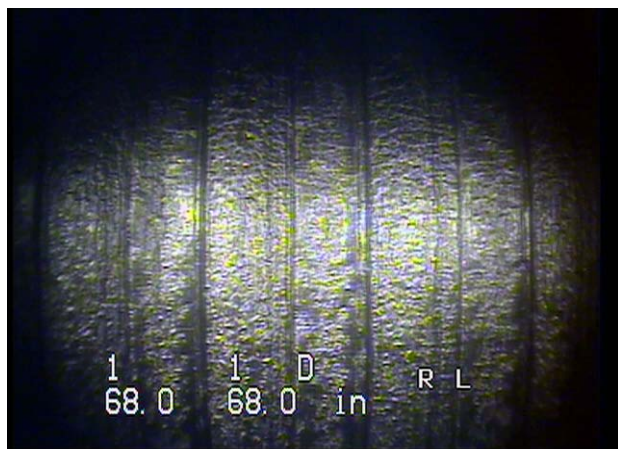
1. Visual Observations cont'd, Ta-10W Tube



1 Round



375 Rounds



750 Rounds



900 Rounds



RDECOM

Large Caliber Work

Explosive Bonded Liner 105MM



RAREfaction waVE gun (RAVEN)

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

- **Potential First DoD Users/Follow-on Implementation**
 - General Dynamics
 - Watervliet Arsenal
- **Responsible DoD/Service Programs**
 - PM CRAM
 - PM Bradley
- **Planned Future Technology Transfer Activities**
 - Leverage PM Support, Demonstrate to PM's
 - Institutional/Regulatory Barriers
 - None Known
- **Process Uses Traditional Metal Working Machinery**
 - No Investment In New Machinery, Buildings or Coating Apparatus



Results

• Previously Related Demonstrations

Under SERDP program WP-1426, verified the Explosive Bonding technology

- Explosively Bonded six 12", four 36" truncated 25mm barrels
- Explosively Bonded and test fired two full length M242 25mm barrels

Under ESTCP program WP-101111 verify the robustness of the Explosive Bonding technology

- Fully fabricated four Explosively Bonded full length M242 25mm barrels
- Test fired one barrel using original M919 APFSDS (HES-9053 propellant)

• Data Summary

- Initially proof fired M793TP-T projectiles
- Successful testing at YPG was demonstrated using over 12,000 aggressively fired rounds (M793/M791) 200 rounds per minute
- Ta-10W Barrel achieved a round count of three times the current baseline of chrome
- Successful testing at YPG was demonstrated using over 900 aggressively fired rounds (M919 APFSDS) 200 rounds per minute

Innovation is realized in:

- **The use of Explosion Bonding in applying refractory metals in gun barrels**
- **Use of advanced rifling/metalworking techniques (Patent Pending)**
- **Use of XRAY Tomography for NDT inspection of weapons**
- **Use of Laser scanner creating a 3D model "cloud of points" of weapon**
- **Recent Awards**
 - **2009 Army Research and Development Achievement (RDA) Award
EB Bonding and Machining Technologies**
 - **2009 Defense Manufacturing Excellence Award Tantalum Tungsten
Cannon Barrel Rifling Technology**
 - **2011 Army Science Conference R&E Award**



Questions?

Frank.e.campo.civ@mail.mil

518-266-4770